

Edward Teller Science & Technology Education Symposium

Radiocarbon Dating 101

Morning Discussion:

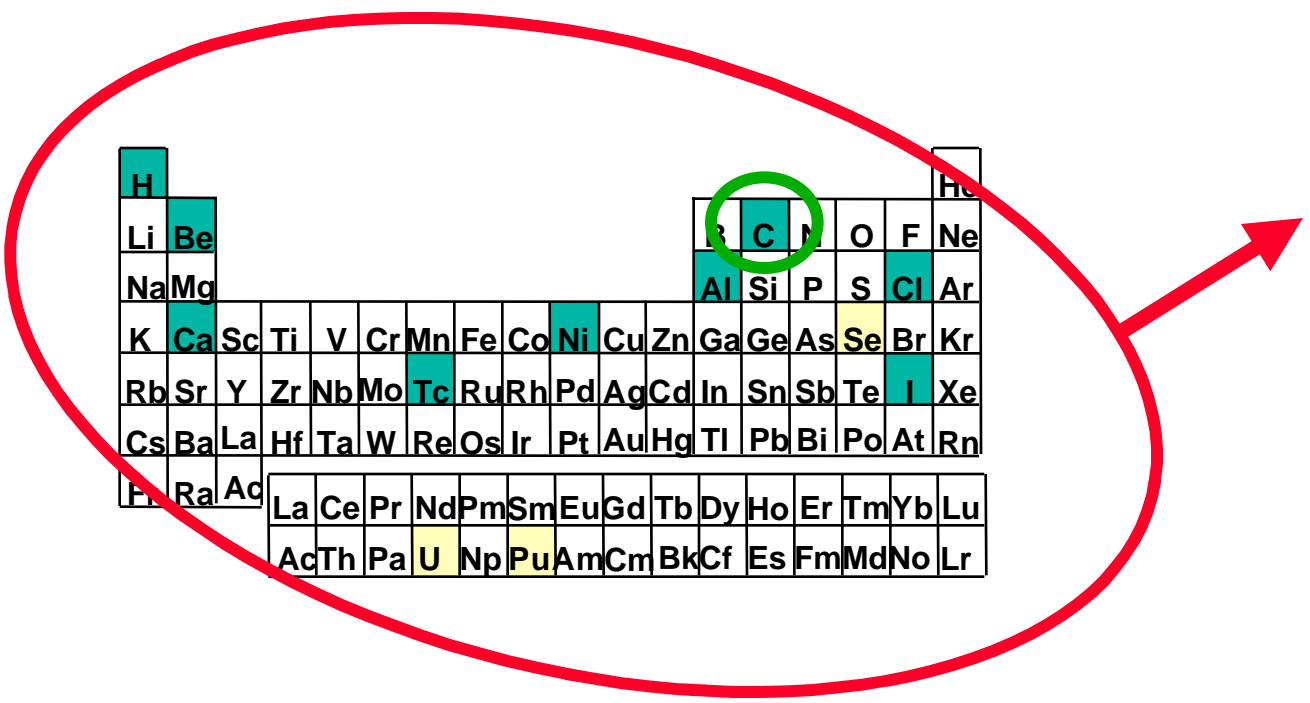
Andrea Cook, Stan Hitomi

UCRL MI 140404

11/3/00

CAMS can measure many different isotopes

Today we will focus on carbon.



H																			He
Li	Be											B	C	N	O	F	Ne		
Na	Mg											Al	Si	P	S	Cl	Ar		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Fr	Ra	Ac																	
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

Top Ten Frequently Asked Questions

- n* What is radiocarbon?
- n* How does radiocarbon dating work?
- n* How do we know radiocarbon dating works?
- n* What kinds of things can and cannot be dated?
- n* Oldest thing that can be radiocarbon dated? Youngest?

Top Ten Frequently Asked Questions

- n* How much material is needed?
- n* How much does it cost?
- n* What famous things have been radiocarbon dated?
- n* Has it provoked any arguments?
- n* How has radiocarbon dating changed history?

What is radiocarbon?

- n* Radioactive isotope of carbon (^{14}C)
- n* Extra neutron makes the nucleus unstable
- n* Same chemical properties as ^{12}C , just a different mass
- n* Rare - one ^{14}C atom for every 1,000,000,000,000 ^{12}C atoms

Isotope	Protons	Neutrons	Proportion	Half Life
^{12}C	6	6	99%	stable
^{13}C	6	7	1%	stable
^{14}C	6	8	0.0000000001%	5,730 years

How rare is radiocarbon?

n **1 in a trillion
(1,000,000,000,000)**

n **If ^{14}C atoms were
people, there would be
at most ONE ^{14}C atom
on the whole earth!**

How does radiocarbon dating work?

Essential concepts.

atmosphere living
plants &
animals

n ^{14}C is made naturally in the upper atmosphere at a known rate

n Living plants and animals continuously ingest ^{14}C and are in ^{14}C equilibrium with the atmosphere

in ^{14}C equilibrium

n When organisms die, they cease to absorb new ^{14}C . The original ^{14}C decays and is not replaced.

How does radiocarbon dating work?

A little more detail

How do we calculate an age?

- n* The time since a death can be calculated
- n* Based on the known decay rate of ^{14}C to ^{14}N
- n* ^{14}C has a half-life of 5730 years
- n* Good for about 10 half-lives or 50,000 years

Willard F. Libby

- n* Invented the radiocarbon dating method
- n* Was working at the University of Chicago with a team of scientists
- n* Won Nobel Prize in Chemistry in 1960

How do we know that it works?

- n* Traditional method - radiocarbon date objects of known age, see if the correct age is obtained.

Or - Use annual tree rings to go back in time

Or- compare with other dating methods

- n* Radiocarbon is not the only dating method**
 - n* For corals - Uranium/Thorium dating**
 - n* For pottery & sediments - Thermoluminescence**
 - n* For obsidian - Obsidian hydration**
 - n* For teeth - Electron spin resonance**
 - n* For eggshells and bones - Amino Acid Racemisation dating**

What kinds of things can be dated?

n **Plants** - wood, twigs, leaves, seeds, pollen, peat, charcoal

n **Animals** - bone, leather, hair, feces, blood, antlers, horns, egg shells, fish remains, insect remains, shells, coral, foraminifera

What other kinds of things can be dated?

- n Things made (ultimately) from plants or animals - paper, fabrics, textiles, soil**
- n Things containing carbon from the atmosphere or any of the above - water, ice cores, air, lake sediments, mud, iron, metal casting ores, pottery**

What can NOT be dated?

- n* **Things that are too old**
- n* **Things that are too young**
- n* **Things that don't get their carbon from the air** (aquatic creatures, animals that eat seafood)
- n* **Fossil fuels, petroleum products, oil paints**
- n* **Fossils** (almost always too old, rarely contain original carbon, preservatives interfere)

Oldest object dateable by radiocarbon?

n **About 50,000 years**

n **Or 10 half-lives**

n **Beyond this, there is hardly any ^{14}C left in the sample**

n **Contamination becomes a big problem**

Youngest object dateable by radiocarbon?

1951

1971

1991

Does radiocarbon age equal calendar age?

n **No !!!**

n Must convert ^{14}C age to calendar age

n ^{14}C age is based directly on the proportion of ^{14}C in the sample

n Doesn't account for-

n Variation in ^{14}C production

n True half-life, 5730 not 5568

n Changes since 1950

How much material is needed?

- n* Very little
- n* AMS requires 1 milligram of carbon (less than a grain of rice)
- n* Other methods require more
 - n* Gas proportional counting (grams)
 - n* Liquid scintillation counting (grams)

How much does it cost?

- n* A radiocarbon date from CAMS costs \$300 - \$600
- n* A date from a non-AMS laboratory costs less, about \$250
- n* The CAMS machine itself is worth about \$7 million
- n* Newer, smaller AMS machines cost > \$1 million

Famous things that have been radiocarbon dated...

***n* The Dead Sea Scrolls**



- n* Radiocarbon date 100BC - 100AD**
- n* Close to dates written on them**
- n* Close to dates estimated based on writing style**

Famous things that have been radiocarbon dated...

***n* Iceman**

- n* Found in northern Italy in September, 1991**
- n* Bones, grass boot, leather and hair were dated**
- n* Shown to live 5,500 years ago (3300-3100 BC)**
- n* When people first began to use copper in Europe**

Famous things that have been radiocarbon dated...

***n* Kennewick Man**

***n* Found in July 1996**

***n* Almost immediately
controversial**

***n* Who owns? Indian tribes?
Local officials? Scientists?**

***n* Bone dated - 9,000 years old!**

***n* Clearly pre-Columbian**

What arguments (if any) have been provoked because of the use of radiocarbon dating?

***n* Shroud of Turin**

***n* Supposed burial cloth of Jesus**

- n* In 1980's Archbishop of Turin gave permission to date it**
- n* Known history of the cloth dates back to mid 14th century**
- n* Contained pollen from Israel**

What arguments (if any) have been provoked because of the use of radiocarbon dating?

- n* Samples were sent to 3 labs -Tucson (USA), Oxford (England) and Zurich (Switzerland)**
- n* Results all very consistent- between AD 1260 and AD 1390.**
- n* Fits closely with first appearance in history (mid 14th century)**
- n* Strongly suggests that the artifact is from the Middle Ages, rather than a genuine 2000 year old burial cloth**

How has radiocarbon dating changed the way scientists are able to interpret and understand history?

- n* Revolutionized the approach to dating the past almost overnight**
- n* Before the 1950's, had to depend on historical records and context**
- n* There was no way of knowing the precise age of an artifact or site**
- n* One of the most critical discoveries of 20th century science**